L. SUPERIOR

A Johnson

THE

ONTARIO WATER RESOURCES

COMMISSION

BIOLOGICAL SURVEY

OF

NIPIGON BAY

1966 - 1967

BIOLOGICAL SURVEY

OF

NIPIGON BAY

1966 - 1967

by

M. J. German
Biology Branch

March, 1968

TABLE OF CONTENTS

SUMMARY

This report deals with biological and water sampling surveys performed on Nipigon Bay in May, 1966 and August, 1967.

Sanitary wastes from the townsite of Red Rock and process wastes from Domtar Newsprint Limited are discharged to the northwestern portion of Nipigon Bay, several hundred feet north of Five Mile Point. At this point of entry, extremely high concentrations of solids, COD, phenols, iron and sulphides were detected by chemical analyses. Concentrations of these parameters were greatly reduced within a short distance from this point of introduction. Comparative studies of threshold odours of the water, tainting of fish flesh and standing crops of bottom fauna throughout the bay revealed water quality impairment in the vicinity of Domtar Newsprint Limited. Specifically, these studies revealed the presence of objectionable odour in the surface water between the point of wastes discharge and Five Mile Point, unpalatable flavour of flesh in fish secured from the same general area and elimination and replacement of indigenous bottom fauna by pollution-tolerant forms within a one and one-half mile radius of the wastes source.

CONCLUSION AND RECOMMENDATIONS

On the basis of chemical and biological data collected from Nipigon Bay, it is clear that waste discharges to the bay from Red Rock adversely influence the quality, variety and abundance of aquatic life indigenous to the bay, within a restricted area. The pollution has broader implications insofar as the quality of marketable fish species is concerned.

Maximum utilization of the Nipigon Bay fishery is dependant upon a high standard of water quality. The following recommendations are made:

(1) Domtar Newsprint Limited should remove from their waste discharge, those substances which contribute to affecting the palatability of water and the tainting of fish flesh.

(2) Waste treatment facilities should be provided by the Improvement District of Red Rock and Domtar Newsprint Limited to minimize as much as possible the impact of sanitary and industrial wastes on the water quality of Nipigon Bay.

BIOLOGICAL SURVEY OF NIPIGON BAY, 1966-1967

INTRODUCTION

Physical, chemical and biological parameters of water quality were examined on the Lower Nipigon River and Nipigon Bay in May, 1966 and August, 1967. It is the purpose of this report to integrate these findings in order to: (1) establish the water quality of the study area; (2) relate water quality to specific wastes sources; (3) discuss the effects of water quality on major uses of this resource; and (4) offer recommendations in the interest of protecting all uses of these waters.

GENERAL DESCRIPTION OF THE STUDY AREA

The Nipigon River watershed drains approximately 10,000 square miles of the Canadian Shield. This river is the only outflow from Lake Nipigon which functions as the central storage reservoir for most of the drainage basin. Discharge rates are controlled at the Pine Portage hydro-generating station. The average daily flow from Lake Nipigon between 1950 and 1965 was 12,900 cfs, while maximum and minimum daily flows of 22,600 cfs and 2,080 cfs were recorded on August 23, 1964 and September 4, 1926, respectively. From the Pine Portage station the Nipigon River flows southward, widening below the townsite of Nipigon to form the inner portion of Nipigon Bay. Nipigon Bay extends approximately 25 miles eastward and 10 miles southward from the mouth of the Nipigon River. Flow

from the river divides into two channels within the inner bay. One channel extends southward along the western shore of the bay to Nipigon Strait and Lake Superior, and the other progresses eastward for approximately 25 miles to Simpson Channel and Lake Superior.

WATER USES

Water supply

Sources of domestic water supply for the townsites of Nipigon and Red Rock are the Nipigon River and Nipigon Bay, respectively.

Domtar Newsprint Limited, which uses in excess of 20 million gallons of water per day in the processing of pulp, is the principal consumer of water from Nipigon Bay.

Waste disposal

Domestic wastes from the townsite of Nipigon (population 2,666) are discharged to the Nipigon River following primary treatment. The sanitary wastes from Red Rock (population 1,900) are discharged without treatment to Nipigon Bay.

Process wastes from Domtar Newsprint Limited are the major source of pollutants entering the bay. This plant produces approximately 600 tons per day of Kraft linerboard and 200 tons per day of newsprint.

The insecticide DDT is an additional contaminant having access to Nipigon Bay. Between 1945 and 1966 this insecticide was applied by Ontario Hydro to several streams in the vicinity of Cameron Falls for control of black fly larvae. Total treatments amounted to 90 gallons of DDT EM-2 emulsifiable concentrate per year between 1945 and 1965 and 45 gallons of DDT EM-2 emulsifiable concentrate in 1966. DDT is a chlorinated hydrocarbon insecticide of extremely stable composition. It is concentrated in the tissue of most aquatic organisms and has been shown, if present in sufficient concentrations, to cause mortality of newly hatched lake trout fry (Burdick et al. 1964).

Recreational use

At present, the recreational potential of Nipigon Bay has been little developed. However, with the Trans Canada Highway recently completed west of Marathon, development of a thriving tourist industry in the region appears very probably. Also, on the basis of social and economic trends in Northwestern Ontario, (Ontario Department of Economics, 1959) it is logical to predict that an increasing number of local inhabitants will utilize the bay for boating and angling.

Commercial fishery

In the past, the major use of Nipigon Bay other than for waste assimilation has been the commercial exploitation of several fish species. The bay supports a variety of potentially exploitable fishes. Listed in order of economic importance, these include: walleye, *Stizostedion vitreum*; whitefish, *Coregonus clupeaformis*; lake trout, *Salvelinus nameycush*; cisco, *Coregonus* sp.; yellow perch, *Perca flavescens*; and smelt, *Osmerus mordax*. Of these species, the walleye has been considered the mainstay of the fishing industry in the bay.

In the last decade, changes in the walleye population of Nipigon Bay have reduced this fishery from one of major proportions to a level where commercial exploitation is no longer considered to be profitable. These changes have included: (1) a deterioration in flesh quality (unnatural flavour) resulting in market rejections and financial losses to the fisherman (Association of Commercial Fishermen of Thunder Bay District, personal communication) (2) a decreasing catch-per-unit-of-effort related to a decline in abundance. (3) the disappearance of walleye from their spawning bed in the Nipigon River (Ryder, 1968). While other commercial species are still present,marketing problems owing to the unnatural taste and the general impracticality of fishing these species without the insurance of the "blue chip" walleye, has placed the

entire fishery of Nipigon Bay in a dangerous position.

The problems experienced by commercial fishermen in Nipigon Bay were summarized and translated to the Commission in a letter from a spokesman for the Association of Commercial Fishermen of Thunder Bay District. Quotes from the aforementioned letter are as follows:

> "Where the Yellow Pickeral have gone elsewhere to spawn and inhabit, the Whitefish are not so choosey. The Whitefish are still in and around the polluted area but there is no sense catching them as they are not saleable."

and

> "Direct losses were incurred by Mr. Gordon Dampier in 1961 of $2,500 when his Whitefish were rejected and dumped. Mr. Harold Dampier experienced $500 in losses in like manner. These men were told by the Baltimore Fish Company not to ship any more to them as they would not accept them at all in the future. Other fishermen in this same family along with the two mentioned commenced shipping to Kemp Fisheries of Port Arthur and were similarly told the same thing, however, with a proviso that the shipper guarantee his fish be of an edible quality. Kemp Fisheries in their advice to these men related that their customers in Detroit and Duluth refused to buy anymore Canadian Fish as their customers became nauseated with these fish".

In this letter, the Association of Commercial Fishermen of Thunder Bay District has maintained that wastes from Domtar Newsprint Limited are responsible for direct money losses to members of the association. In addition, the recent changes in the fishery of Nipigon Bay have raised conjecture concerning a possible relationship between

kraft mill wastes which are discharged to Nipigon Bay and the decline in the walleye population.

Limited information indicates that the walleye of Nipigon Bay gained access to their spawning grounds in the Nipigon River by ascending the western channel of Nipigon Bay. It has been postulated that chemical wastes from the Domtar Newsprint Limited might have formed a chemical barrier along the western portion of Nipigon Bay, thereby thwarting accessibility and negating reproduction of walleye on their natural spawning grounds.

METHODS

Water chemistry

Single 40-ounce water samples were collected from Forgan Lake, Jessie Lake, three locations on Helen Lake and 14 locations on the Lower Nipigon River and Nipigon Bay in May, 1966. At six locations in the immediate vicinity of the kraft-mill effluent, replicate water samples were collected on four consecutive sampling days. Approximate locations of these six composite sampling sites were as follows:

Station A	-	200 yards north of discharge
Station B	-	100 yards north of discharge
Station C	-	100 feet south of discharge
Station D	-	300 feet south of discharge
Station E	-	400 feet south-west of discharge
Station F	-	400 feet south-east of discharge

All samples were submitted to the Chemistry Branch of the Commission for determinations of: pH, suspended solids, dissolved solids, COD, turbidity, alkalinity, iron, sulphates, sulphides and phenols.

Threshold odour

Water samples from 15 locations on Nipigon Bay were obtained on August 28, 1967. Threshold odour

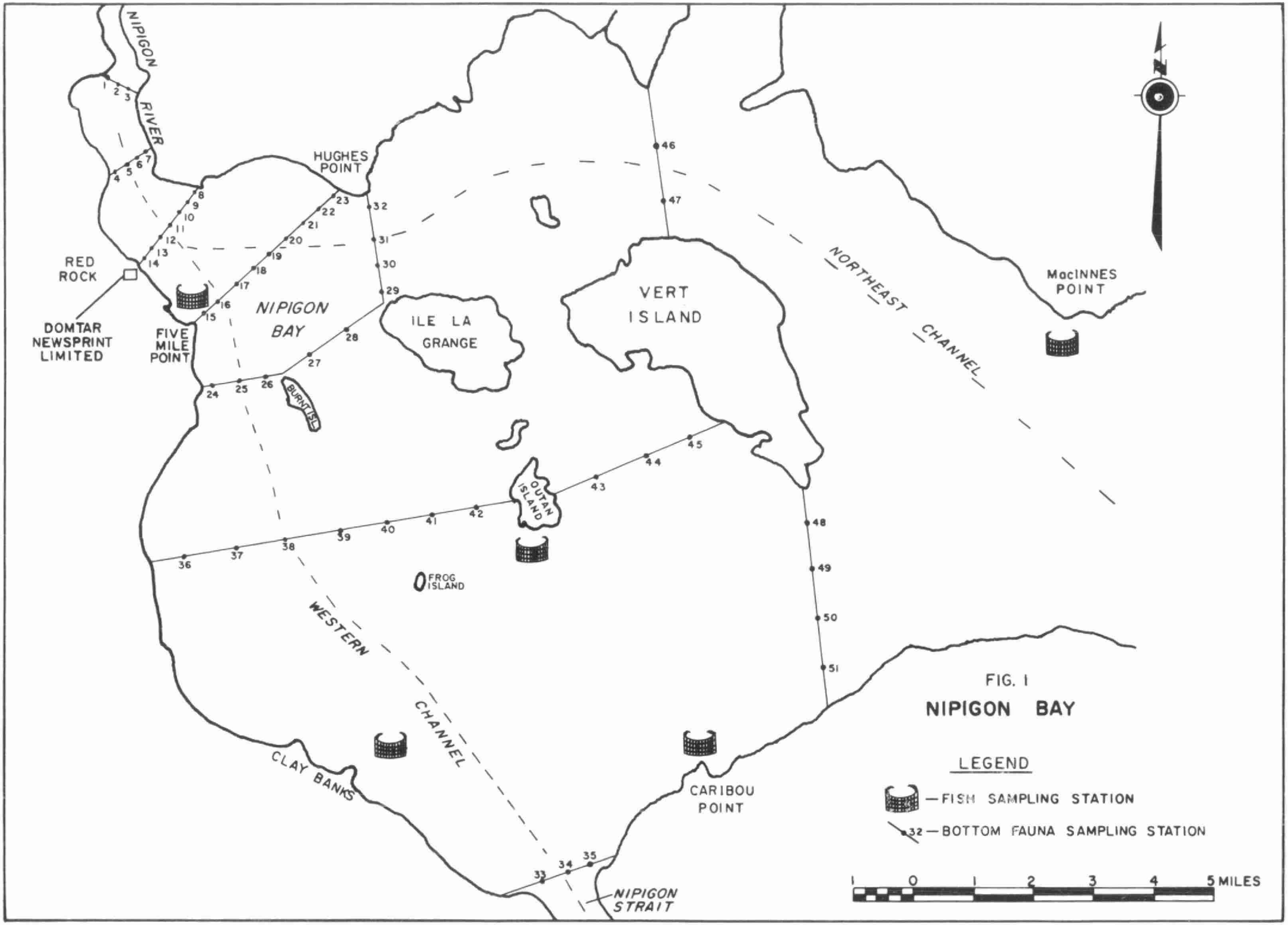

FIG. 1

NIPIGON BAY

determinations were carried out the following day.

Bottom fauna

Single samples of approximately 10 inches square of the bottom sediments were collected at each sample station by means of a Peterson dredge. These samples were sifted through a 30-mesh-per-inch box screen and macroinvertebrates retained by the screen were picked into vials of 95% alcohol. These samples were returned to the laboratory for microscopic identification and enumeration.

Flavour evaluations of fish flesh

Whitefish (*Coregonus clupeaformis*) were gill-netted from Nipigon Bay, eviscerated and frozen by a commercial fisherman from Nipigon during the period from September 23 to November 2, 1967. The fish were then sent via air freight to the Biology Branch at the laboratory in Toronto where they were held in a frozen condition until flavour evaluations were completed.

Seven fish from each of four vicinities.....MacInnes Point (control), Caribou Point, Outan Island and the Clay Banks, and 20 fish from Five Mile Point near the Red Rock Mill, were obtained.

Six panel members participated in seven separate taste evaluation sittings to determine the presence or absence of foreign flavour in the flesh of these fish. Tests were completed during November 21 to November 24, 1967.

DDT residues in fish flesh

Eleven white suckers (*Catostomus commersoni*) were secured off Cook's Point in Nipigon Bay in May, 1966. Gonad, muscle and whole tissue samples of these fish were submitted to the Chemistry Branch for analyses of

DDT residues. Samples were analysed by gas chromatography for DDT and related compounds. Due to the saponification method used, any DDT present was converted into and measured in terms of DDE.

RESULTS

Water chemistry

The results of chemical analyses are presented in Table 1 of the Appendix.

As explained in the section on methods, water samples were collected in the vicinity of the effluent from Domtar Newsprint Limited. Various workers have isolated particular chemicals or groups of chemicals present in kraft wastes which may be toxic to aquatic organisms if present in sufficient concentrations (VanHorn, Anderson and Katz, 1949). The most toxic of these are hydrogen sulphide (H_2S), methyl mercaptans, sodium salts of resin acids and the sodium salts of fatty acids. The literature is less specific concerning components of kraft and sulphite wastes which may provoke avoidance reactions in fishes. With this in mind, it should be noted that the chemical parameters investigated are most useful as an indication of the relative strength of the effluent and the order of dilution. The following table illustrates the results of four composite water samples collected from each of six sampling locations in the vicinity of the waste discharge from Domtar Newsprint Limited. Also included are values for the same determinations on samples collected from Helen Lake, the Nipigon River and average values for eleven samples collected from Nipigon Bay (samples A to F were not included in this average).

Table 1. Chemical characteristics of surface waters of Nipigon Bay and connecting waters in May, 1966.

	COD	Solids Susp.	Solids Diss.	pH	Alkalinity $CaCO_3$	Iron Fe	Phenol (ppb)	Sulphide H_2S
Helen Lake	19	16	119	7.8	74	0.28	3	0.0
Nipigon River	24	13	115	7.7	76	0.27	1	0.0
Nipigon Bay (average)	22	12	97	7.9	75	0.21	7	0.0
A (200 yds. North)	15	8	100	8.0	80	0.23	6	0.0
B (100 yds. North)	16	13	121	8.0	83	0.23	25	0.0
C (100 ft. South)	582	141	722	9.2	164	1.60	75	6.6
D (300 ft. South)	88	16	176	8.3	93	0.54	28	0.0
E (400 ft. S.West)	20	9	99	7.9	81	0.26	19	0.0
F (400 ft. S.East)	18	7	107	8.0	79	0.18	7	0.0

* All values expressed in parts per million (ppm) with exception of pH readings.

Chemical characteristics at station C (100 feet south of effluent) indicate the relative strength of the effluent. Extremely high concentrations of solids, COD, phenols, sulphides and iron were present. The pH and total alkalinity were increased. Examination of the water quality at the surrounding stations provides a fair indication of the relative order of dilution. At station D, 300 feet south of the discharge, sulphides were absent and COD, suspended solids and iron concentration were reduced by factors of 6.6, 8.8 and 3 respectively.

Chemical data for station A (200 yards north of the outflow) and station F (400 feet south-east of the outflow) indicated that these stations had water of comparable quality to the mean value from eleven wide-spread location on Nipigon Bay, and comparable also to water quality on Helen Lake. While it is not possible to draw inferences from these data concerning each of the many chemical components of the waste discharge from Domtar Newsprint Limited, the order of initial dilution suggests that the overall chemical quality of Nipigon Bay, at the time of the survey was not grossly altered by the effluent from Domtar. However, it must be remembered that these samples were collected during spring turnover. It is probable that a greater influence of these wastes on the chemical quality of Nipigon Bay would be demonstrable during summer months when a distinct separation develops between the colder water at the hypolimnion and the warmer, epilimnetic water.

Threshold odours

Odours occur in water because of the presence of foreign substances. The occurrence of unnatural odours in surface waters is detected by the Threshold Odour Number (T.O.N.) which represents the number of times an odour-bearing water must be diluted to obtain a concentration at which the odour is barely perceptible. Generally speaking, a reasonable T.O.N. for water of a potable quality for drinking would be four or less. In addition, sampling for threshold odour determinations is useful in pinpointing the source of contaminants present in surface waters. The findings of threshold odour determinations on water samples secured from Nipigon Bay are listed in Table 2.

Table 2. Threshold Odour levels of the surface water of Nipigon Bay, August, 1967.

Station	Number of Participants	Threshold Odour Number Geometric Mean
5	4	4.8
10	5	2.1
12	4	3.5
14	3	1.8
A*	4	200.0
B*	10	83.2
C*	4	15.3
15	5	50.0
18	4	4.0
20	4	3.5
25	4	2.0
28	3	7.3
30	3	3.0
38	3	3.0
47	4	2.8

A* - 100 feet south of effluent
B* - 200 feet south of effluent
C* - 300 feet south of effluent

These results indicate that a plume of odourous wastes extend southward from the effluent of Domtar Newsprint Limited to Station 15 off Five Mile Point. An abnormally high Threshold Odour with a geometric mean of 200 was detected 100 feet south of the discharge and an offensive level of 50 was present off Five Mile Point. Levels throughout the remainder of the bay were low and cannot be considered abnormal.

Bottom fauna

Bottom fauna at stations 1 to 7 on the Nipigon River were represented by 10 taxa of macroinvertebrates. None of these taxa were significantly abundant, as is typical of large unproductive rivers flowing through the Canadian Shield.

Eight major taxanomic groups of macroinvertebrates were collected from 32 of the stations on Nipigon Bay

which were sampled for bottom fauna. The distribution and abundance of these forms are presented in tables II and III of the Appendix. The isopod Lirceus, leech Dina, biting midge Palpomyia and five genera of molluscs were present in limited numbers at widely separated locations throughout the bay. The most abundant forms were mayfly naiads, amphipods, midge larvae and sludgeworms and the distribution of these taxa and total numbers of individuals represented provide a means for evaluating water quality at the time of the survey.

The pollution-intolerant mayflies Hexagenia limbata and amphipods Ponteporeia affinis co-existed along the eastern shores of the inner bay, between and surrounding Burnt Island and Ile la Grange and throughout the outer bay. These and other pollution-intolerant organisms were not present at locations 34, 38, 25, 15, 16, 17, 18, 19, 12, 13 and 14. These locations were in a semi-circle surrounding the Red Rock Mill and in the center of the westerly channel flowing to Nipigon Strait.

Midge larvae, which as a group are either pollution-tolerant or facultative, were the only group taken consistently throughout the bay. Provisional identification indicated that representatives of 12 or more species of midge larvae were present in the samples collected. Species diversity became greater with increased distance from the discharge of the Red Rock Mill, suggesting that the facultative forms had been eliminated from the same general area as the pollution-intolerant mayflies and amphipods.

Sludgeworms in association with pollution-intolerant forms were present in low densities throughout the bay, but were only abundant at stations devoid of the intolerant forms. Sludgeworms respond positively to organic pollution but may be limited in numbers owing to toxic pollution.

The low densities of sludgeworms and absence of other taxa in the immediate vicinity of Domtar Newsprints Limited (Stations 14 and 15) were suggestive of a toxic environment. Organic pollution was indicated by an increase in density of sludgeworms further out from the discharge area.

On the basis of biological parameters, the organic pollution extends outward in a semi-circle for a distance of approximately one and one-half miles from the mill and appears to extend southward along the westerly channel of the bay to Nipigon Strait.

Flavour evaluations of fish flesh

Table IV of the Appendix presents the data obtained on the incidence and intensity of foreign flavour in each fish specimen evaluated. In table 3 below, the data are condensed to total numbers of samples tested from each location. Also, this table indicates the incidence of foreign flavour on a percentage basis.

Table 3. Incidence and intensity of foreign flavour in fish samples from Nipigon Bay, August, 1967.

Collection Site	Number of Samples	0	+	++	+++	Total Positive	Definite or Strong
MacInnes Point	39	26	7	5	1	13	6
(control)	100%	67%	18%	13%	2%	33%	15%
Red Rock	111	10	23	30	49	101**	79**
Mill	100%	9%	21%	27%	45%	92%	71%
Outan	39	27	10	1	1	12	2
Island	100%	69%	26%	2%	2%	31%	4%
Clay Banks	39	27	7	1	4	12	5
	100%	69%	18%	2%	10%	31%	13%
Caribou	39	30	7	2	0	9	2
Point	100%	77%	18%	5%	0%	23%	4%

* 0 - no foreign flavour present
\+ - foreign flavour - barely perceptible
++ - " " - definite
+++ - " " - strong
** - Significantly different from control at 1% level.

It can be seen that in the control group 33% of the flesh samples possessed a foreign flavour and 15% of the control group possessed a definite to strong flavour. These percentage figures were similar to the flavour ratings of the fish from Outan Island, the Clay Banks and Caribou Point. Of the 111 flesh samples tastes from the vicinity of the Red Rock Mill, 92% were rated as having a foreign flavour and 71% were considered to possess a definite to strong flavour.

If 60% or more of the flesh samples from an individual fish are rated by the taste panel as possessing a definite or strong foreign flavour, it can be assumed that that individual fish is tainted. On this basis, none of the fish from MacInnes Point, Caribou Point, Outan Island and the Clay Banks would be considered tainted, while fully 80% of the fish taken from the vicinity of the Red Rock Mill were shown to possess an objectionable flavour.

When the incidence of unnatural flavour in the control group is compared, using a Chi square test, to the incidence of abnormal flavour in the fish from the mill area, it is found that the difference between these two groups is highly significant at the 99% confidence level, i.e. the population of fish from the mill area had a much higher incidence of foreign flavour than could be expected based on the control group. Put another way, there is a 1% probability that the data found could have occurred by chance. It can also be demonstrated by the Chi square test that there were no significant differences between the levels of foreign flavour in the control fish and fish from Outan Island, Caribou Point and the Clay Banks.

The adjectives used to describe the flavour of the tainted fish were sawdust-like, gasoline-like, pulpy, chemical and musty.

DDT residues in fish flesh

Low levels of DDE (<1.0 ppm) were detected in the body tissues of each of the fish analysed for DDT residues. However, no hazard would be anticipated from consumption of fish containing these relatively low levels of DDE, nor would the natural reproductive capacity of these fish be affected on the basis of information now available. Wisconsin researchers subjected walleye eggs and fry to a series of experiments designed to determine the effects of DDT residues on reproduction of that species. Levels of 0.1 to 0.9 ppm DDT in the eggs and 0.1 to 10 ppm DDT in the fry were measured but these levels could not be associated with poor walleye production (Kleinert, S. J.,1967). It is recognized that DDT is concentrated to the greatest extent in fatty tissues of fish. Assuming that walleye (*Stizostedion vitreum*) concentrate DDT in a similar manner and to an equal or lesser extent than the white sucker, which is reasonable considering the greater proportion of fatty tissue present in suckers, it is unlikely that the DDT black fly control programme at Cameron Falls would have been responsible for the disappearance of walleye in Nipigon Bay.

IMPACT OF EXISTING POLLUTION ON THE FISHING RESOURCE

Although limited in total extent, changes in the aquatic environment and corresponding shifts in aquatic populations have been demonstrated in Nipigon Bay. Water quality changes in the vicinity of the Red Rock Mill have altered the bottom fauna from pollution-intolerant to tolerant forms. The significance of this change on the fishery of Nipigon Bay lies in the respective influence of pollution-intolerant and tolerant forms of bottom fauna on higher trophic levels, especially fish. The intolerant mayflies and amphipods are valuable food

organisms which support game and commercial fish species, whereas pollution-tolerant sludgeworms are less desirable in that they favour the maintenance of coarse fish populations at the expense of the former.

Some factor, or combination of factors, has all but eliminated the walleye from Nipigon Bay. In 1958, 1959 and 1960 commercial catches of walleye from the bay were 23,527, 12,879 and 4,652 pounds respectively. In 1962, the catch declined to 672 pounds and only 76 pounds were secured in 1965. Commercial fishing was not carried out in 1961 and 1963. Unfortunately, this study has not provided an explanation for the decrease in walleye numbers.

Sixteen of 20 whitefish secured off Five Mile Point in Nipigon Bay were classified as unpalatable when evaluated by the taste panel technique. On the other hand, none of the fish from the Clay Banks, Outan Island, Caribou Point and MacInnes Point were classified as such. The acquisition of unnatural flavour in fish flesh has serious implications for the sport and commercial fishery of Nipigon Bay. Financial losses previously documented in this report have been experienced by commercial fishermen from Nipigon. Not only are the fishing grounds in the vicinity of Five Mile Point unexploitable, but the likelihood exists that effected individuals will occasionally be picked up elsewhere in the bay. The climate concerning tainted fish is such that a few rejects could result in a closed market for all fish netted from Nipigon Bay and jeopardize the good standing of fisheries operating on Lake Superior, at large.

Notwithstanding the recent disappearance of walleye, in the future there will be a significant potential for sport fishing and commercial exploitation of the remaining species provided no further alteration occur in variety or abundance of fish and that the quality of fish flesh secures market and anglers' acceptance.

REFERENCES

VanHorn, Willis M., J. B. Anderson and Max Katz. 1949. The effect of kraft pulp wastes on some aquatic organisms. Trans.Amer.Fish Soc., 79 (1949): 55-63.

Ontario Department of Economics. 1959. Lakehead Northwestern Ontario Region - Economic Survey. 96 pp.

Ryder, R. A. Dynamics and exploitation of mature walleyes (Stizostedion v vitreum (Mitchill), in the Nipigon Bay region of Lake Superior. In press.

Burdick, G. E., E. J. Harris, H. J. Dean, T. M. Walker, Jock Skea, and David Colby. 1964. The accumulation of DDT in lake trout and the effect on reproduction. Trans. Amer. Fish Soc. Vol. 93(2): 127-136.

Kleinert, Stanton J. 1967. Runaway pesticides. Wisconsin Cons. Bull. Vol. 33(1): 22-24.

Report prepared by:

M J German

M. J. W. German
Biologist.

Report approved by:

C. F. Schenk

C. F. Schenk, Supervisor
Biology Branch,
Division of Laboratories

APPENDIX

Table I. Chemical characteristics of near-surface waters of the Nipigon River, Nipigon Bay and connecting lakes. Sampling locations are described in the section on methods or shown on Figure I.

Station	Total	Susp.	Diss.	pH	COD	Turbidity Units	Alkalinity $CaCO_3$	Iron Fe	Sulphate SO_4	Sulphide H_2S	Phenol (ppb)
Forgon Lake	102	1	101	-	-	-	78	0.07	2	0.0	2
Jessie Lake	116	1	115	-	-	-	85	0.05	3	0.0	4
Helen Lake											
1	142	14	128	7.6	27	5.0	77	0.24	5	0.0	0
2	136	20	116	8.0	23	6.5	72	0.34	2	0.0	4
3	130	15	115	8.0	8	8.5	74	0.26	2	0.0	4
Nipigon River and Bay											
2	124	13	111	8.0	23	4.0	75	0.22	2	0.0	0
5	130	13	117	7.4	27	9.0	76	0.26	3	0.0	4
7	130	13	117	7.8	23	4.5	76	0.32	4	0.0	0
8	50	12	38	7.8	31	7.5	81	0.23	4	0.0	10
10	118	13	103	7.8	23	6.0	72	0.22	4	0.0	4
11	122	13	109	7.9	27	4.5	74	0.24	5	0.0	4
12	124	13	112	8.0	19	4.5	77	0.25	3	0.0	8
13	98	23	75	8.0	19	11.0	78	0.30	3	0.0	0
14	118	14	104	8.0	19	5.5	77	0.36	4	0.0	20
15	134	11	123	7.9	27	7.0	81	0.20	3	0.0	4
17	110	10	100	7.9	19	6.0	72	0.15	4	0.0	12
19	114	9	105	7.9	19	7.0	69	0.12	3	0.0	4
21	104	9	105	7.9	19	5.5	74	0.10	4	0.0	4
34	110	8	102	7.9	0	-	74	0.10	4	0.0	4
Red Rock											
A	108	8	100	8.0	15	-	80	0.23	3	0.0	6
B	134	13	121	8.0	16	-	83	0.23	3	0.0	25
C	813	141	772	9.2	582	-	164	1.60	54	6.6	75
D	192	16	176	8.3	88	-	93	0.54	11	0.0	28
E	108	9	99	7.9	20	-	81	0.26	4	0.0	19
F	114	7	107	8.0	18	-	79	0.18	2	0.0	7

Table II. Macroinvertebrates collected at 35 stations on the Nipigon River and Nipigon Bay in May, 1966.

STATION	DEPTH	*Caenis*	*Ephemerella*	*Ephemerella simulans*	*Hexagenia limbata*	*Lirceus*	*Ponteporeia affinis*	*Hyallela azteca*	*Pisidium*	*Sphaerium*	*Amnicola*	*Lyogyrus*	*Valvata*	Chironomidae	*Palpomyia*	Oligochaeta
1	75													16		8
2	40													5		
3	5							1						35		1
4	35				9						1			3		2
5	50								3	2				2	1	1
6	50								2	2				10		11
7	20			1	2							1		13		
8	15			1	6									10		
9	20				12		4							3		4
10	42					1	3			2				3		
11	50						6				1		1	1		
12	70													36	1	
13	65											1		9		100
14	35													1		
15	55													27		3
16	75													3		45
17	85													10		140
18	85													18		210
19	58													12		1
20	49								3					25		
21	35						4							3		
22	4		1	3		11	1	1						9		1
23	3						1		1					15		4
24	10			2	2	1		4						5		2
25	50													37		6
26	40				7		34							1	1	
27	42				1		18		1					3		
28	45				1		30			1				2		
29	75						25							2		
30	10								2					14		
31	10	1		2		3	2	21				1		11		
32	10			2	10	1								6		
33	145					1	4		15					44		12
34	180								1			1		3		103
35	85						1		1					7		27

Table III. Macroinvertebrates collected at 12 stations on Nipigon Bay in August, 1967.

	12	15	16	18	21	28	30	34	38	41	46	64
Mayfly												
Hexagenia				1	7					26		
Amphipod												
Ponteporeia affinis				19		13	17			5	45	44
Molluscs												
Pisidium	2		7	5		12	10	8		3		
Sphaerium			1	1						1		
Amnicola				3	4					7		
Valvata					1					4		
Midge												
Chironomidae	1	4	8	2	16		6	8	5	15		1
Worm												
Oligochaeta	41	350	6		4	3	1	270	30	3	10	8

Table IV. Incidence and intensity of foreign flavour in individual fish.

Fish Number	Number of Samples	No. of samples with foreign flavour 0	+	++	+++	Total Positive	Total Definite or Strong
MacInnes Point							
1	5	3	1	1	0	2	1
2	5	2	1	1	1	3	2
3	5	4	0	1	0	1	1
4	6	5	0	1	0	1	1
5	6	3	2	1	0	3	1
6	6	4	2	0	0	2	0
7	6	5	1	0	0	1	0
TOTAL	39	26	7	5	1	13	6
Redrock Mill							
1	5	0	2	1	2	5	3
2	5	0	2	2	1	5	3
3	5	1	2	2	0	4	2
4	5	0	2	2	1	5	3
5	5	1	2	1	1	4	2
6	5	1	2	0	2	4	2
7	5	1	1	2	1	4	3
8	5	1	0	2	2	4	4
9	5	1	1	0	3	4	3
10	6	1	0	4	1	5	5
11	6	0	1	3	2	6	5
12	6	0	4	0	2	6	2
13	6	0	2	2	2	6	4
14	6	0	0	5	1	6	6
15	6	0	0	2	4	6	6
16	6	1	1	1	3	5	4
17	6	1	0	0	5	5	5
18	6	1	0	0	5	5	5
19	6	0	0	0	6	6	6
20	6	0	1	1	4	5	4
TOTAL	111	10	22	30	49	101	78
Outan Island							
1	5	5	0	0	0	0	0
2	5	1	3	1	0	4	1
3	5	4	1	0	0	1	0
4	6	3	2	0	1	3	1
5	6	5	1	0	0	1	0
6	6	5	1	0	0	1	0
7	6	4	2	0	0	2	0
TOTAL	39	27	10	5	1	13	6
Clay Banks							
1	5	5	0	0	0	0	0
2	5	3	2	0	0	2	0
3	5	4	1	0	0	1	0
4	6	4	1	0	1	2	1
5	6	3	1	0	2	3	2
6	6	6	0	0	0	0	0
7	6	2	2	1	1	4	2
TOTAL	39	27	7	1	4	12	5

Table IV. (continued...)

Fish Numer	Number of Samples	No. of samples with foreign flavour 0	+	++	+++	Total Positive	Total Definite or Strong
Caribou Point							
1	5	3	2	0	0	2	0
2	5	4	0	1	0	1	1
3	5	4	1	0	0	1	0
4	6	5	1	0	0	1	0
5	6	4	1	1	0	2	1
6	6	4	2	0		2	0
7	6	6	0	0	0	0	0
TOTAL	39	30	7	2	0	9	2

* 0 – no foreign flavour present

\+ – Foreign flavour – barely perceptible

++ – " " – definite

+++ – " " – strong

** – Significantly different from control at 1% level